TECHNICAL SPECIFICATION

ISO/TS 13475-2

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Acoustics — Stationary audible warning devices used outdoors —

Part 2: Precision methods for determination of sound emission quantities

Acoustique — Dispositifs d'alarme sonore fixes utilisés à l'extérieur —

Partie 2: Méthodes de laboratoire pour le mesurage des grandeurs d'émission acoustique

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed every three years with a view to deciding whether it can be transformed into an International Standard.

Attention is drawn to the possibility that some of the elements of this part of ISO 13475 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13475 consists of the following parts, under the general title *Acoustics — Stationary audible warning devices used outdoors*:

— *Part 1: Field measurements for determination of sound emission quantities*

— *Part 2: Precision methods for determination of sound emission quantities*

Introduction

ISO 13475-1 describes field measurements. The test methods are intended to produce field test values of the sound emission level of the siren as it is installed in an outdoor situation. These field test values may, within the uncertainties, be used to control the specifications of delivered sirens, or to compare the performance of different sirens under the same conditions emitting the same signals.

ISO/TS 13475-2 describes precision measurements. This method is intended to produce generally valid specification of sirens for type tests, acceptance test or for use in the design of outdoor warning systems, etc.

In this part of ISO 13475, two types of precision measurements are discussed. They are:

a) **free-field measurements**, which are applicable to measurements in an anechoic chamber or outdoors at large height;

b) **measurements in a free field over a reflecting plane**, which are applicable to measurements in semi-anechoic rooms or outdoors using a flat plate with perpendicular sound incidence (free field with one reflecting plane).

In addition to the tests described in this part of ISO 13475, further tests may be relevant (e.g. tests for the influence of and resistance to cold, heat, humidity, electromagnetic fields, shock and vibration and long-term performance tests). Test methods for phenomena other than acoustic performance are not included in this part of ISO 13475.

Measurements made under optimal conditions in conformity with ISO 13475 should result in the expanded uncertainties given in Table 1.

Table 1 — Uncertainty in the determination of immission-relevant C-weighted sound power levels for stationary audible warning devices

Reference	Measurement method	Expected expanded uncertainty
Part 1: Field measurements	Flat plate	2 dB
	Horizontal	4 dB
Part 2: Precision measurements	—	1 dB

The expanded uncertainty for actual measurement conditions, taking into account the cumulative effect of all causes of measurement uncertainty, can be found in annex B.

Acoustics — Stationary audible warning devices used outdoors —

Part 2:
Precision methods for determination of sound emission quantities

1 Scope

This part of ISO 13475 specifies the test conditions under which the acoustic emission levels of stationary audible warning devices may be obtained. It is applicable to sirens for use in outdoor public warning systems and sound signalling devices for use outdoors.

The purpose of this test code is to be able to produce reliable sound emission level measurements for stationary sirens to be used outdoors.

This part of ISO 13475 does not cover spoken messages and contains no recommendations for specific warning signals.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13475. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13475 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3745, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and semi-anechoic rooms.*

IEC 60942:1997, *Electroacoustics — Sound calibrators*.

IEC 61260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters.*

IEC 61672-1:— [1)], *Electroacoustics — Sound level meters — Part 1: Specifications*.

3 Terms and definitions

For the purposes of this part of ISO 13475, the following terms and definitions apply.

3.1
siren
audible warning device for use outdoors

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1) To be published. (Revision of IEC 60651 and IEC 60804)

3.2
electronic siren
siren that produces tonal sounds by amplifying the output of an electronic signal generator and broadcasting the amplified signal from one or more electrodynamic loudspeakers

NOTE Such sirens may also be used for giving voice messages.

3.3
electromechanical siren
siren that produces tonal sounds by flow interruptions generated in a rotating wheel

NOTE Electromechanical sirens are mechanical sirens driven by an electric motor.

3.4
pneumatic siren
siren that produces sound by periodically interrupting or modulating a flow of compressed air

NOTE The air compressor may be integrated with or separate from the flow interrupter.

3.5
horizontally omnidirectional siren
siren that radiates sound approximately uniformly (within a specified tolerance) in all horizontal directions from the siren at the specified frequency of the sound

3.6
directional siren
siren that radiates most of its sound in one or more specific directions

3.7
rotating or oscillating siren
directional siren that contains a mechanism which slowly rotates its beam of sound about a vertical axis

3.8
immission-relevant sound power level
sound power level from a monopole source that would give the same sound pressure level in the far field as the actual source

NOTE 1 It is expressed in decibels (ref. 1 pW).

NOTE 2 No information concerning the total radiated power can be drawn from $L_{W,\text{imm}}$.

3.9
near field
that part of the sound field with significant interaction between different parts of the siren source

NOTE The sound pressure decay with distance does not follow the inverse square law in the acoustic near field.

3.10
far field
that part of the sound field with insignificant interaction between parts of the siren

NOTE The sound pressure decay with distance follows the inverse square under acoustic free-field conditions.

4 Symbols

$L_{p\mathrm{C}}$	C-weighted sound pressure level (ref. 20 µPa), in decibels
L_p	sound pressure level, in decibels
$L_{p\mathrm{Ceq},T}$	equivalent C-weighted sound pressure level, in decibels, over a time period T
$L_{p\mathrm{Cmax,F}}$	maximum C-weighted sound pressure level, in decibels, measured with time weighting F
$L_{W,\mathrm{imm}}$	immission-relevant sound power level (ref. 1 pW), in decibels
$L_{W\mathrm{C,imm}}$	C-weighted immission-relevant sound power level (ref. 1 pW), in decibels

5 Measurement methods

5.1 General

Two methods for the performance of measurements are described: the free-field method and the flat-plate method. Both methods may be used indoors or outdoors. In all cases the measuring distance shall be chosen in accordance with 5.2.

Measurements of the sound pressure levels produced from outdoor sirens in far-field areas, i.e. at distances larger than 200 m, similar to that defined in this part of ISO 13475, vary widely instant by instant. These variations are due to varying ground cover, localized and regional thermal effects and gradients, phase coherence of the siren, wind conditions, ground surface effects, etc. If applying the results gained from this precision method to an actual planning of a warning system, the large variations due to the above-mentioned effects shall be taken into account.

5.2 Microphone positions

Microphone positions shall be chosen on the qualified measurement line, in accordance with the procedure given in annex C. Windshields shall be used for all outdoor measurements. When choosing the measuring distance, d, the influence of the near-field effects shall be taken into account. A measuring position outside the near field is preferred. This can be fulfilled through relationship (1):

$$d \geqslant (l^2 f)/c \qquad (1)$$

where

- l is the largest vertical dimension of the sound opening (according to 7.3.2.2 and Figure 6);
- f is the highest frequency of interest;
- c is the speed of sound.

If the microphone cannot be located outside of the near field, the location shall fulfil the requirement of relationship (2):

$$d > (l^2 f)/4{,}5\,c \qquad (2)$$

Corrections to the signal output shall then be applied according to 7.3.2.2.

The maximum distance between the siren and the microphone shall not exceed 50 m.

5.3 Free-field method

5.3.1 General

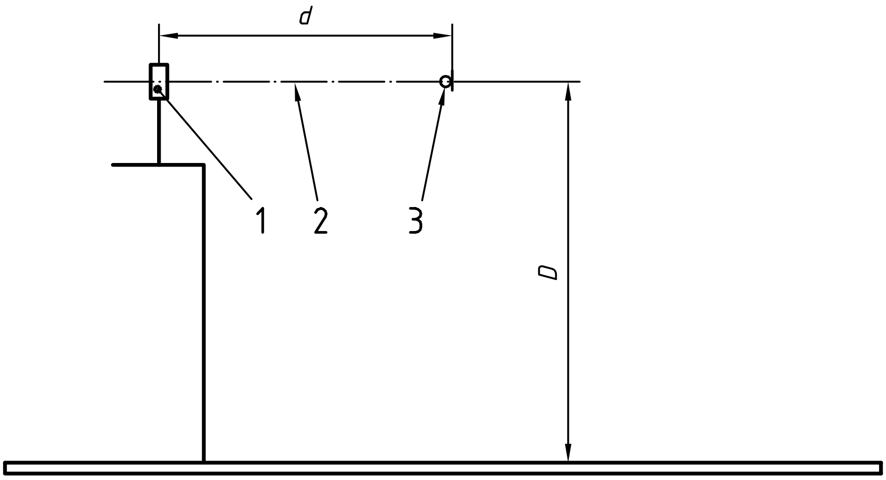
The free-field method may be performed either in an anechoic chamber or outdoors under conditions giving practically no influence from reflecting surfaces (see Figure 1 and annex C).

5.3.2 Anechoic chamber

The test room shall be large enough to comply with the requirements given in 5.2.

5.3.3 Free-field measurement at large height

A typical set-up for a free-field test at large height is shown in Figure 1.



Key

1 Siren

2 Measurement line

3 Microphone

D is the distance from the reflecting surface

d is the measurement distance

Figure 1 — Outdoor test site

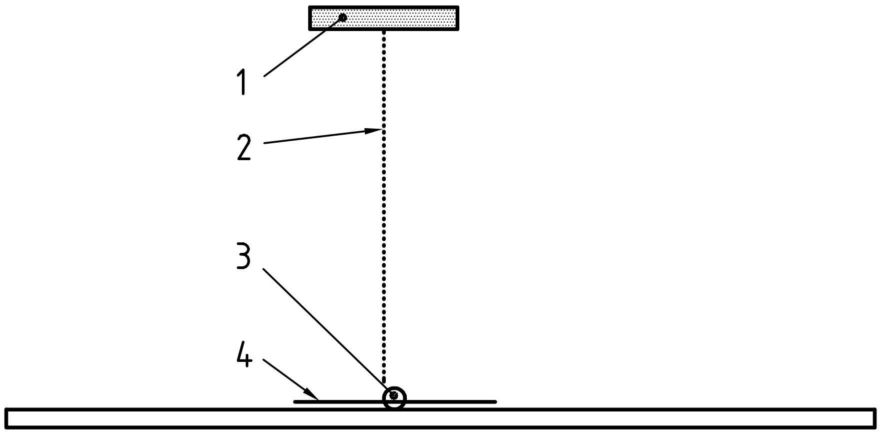
For an outdoor test site to qualify for measurements conforming to this part of ISO 13475, the relevant measuring line shall be in accordance with the requirements given in 5.2.

NOTE Distance $D > 5\ d$ to the nearest reflecting surface is usually sufficient.

5.4 Measurements in a free field over a reflecting plane

5.4.1 General

The flat-plate method may be performed either in a semi-anechoic room or outdoors as shown in Figure 2. The absorption coefficient of the hard surface shall be less than 0,06 over the frequency range of interest.



Key

1 Siren

2 Measurement line

3 Microphone

4 Flat plate or hard surface in semi-anechoic room

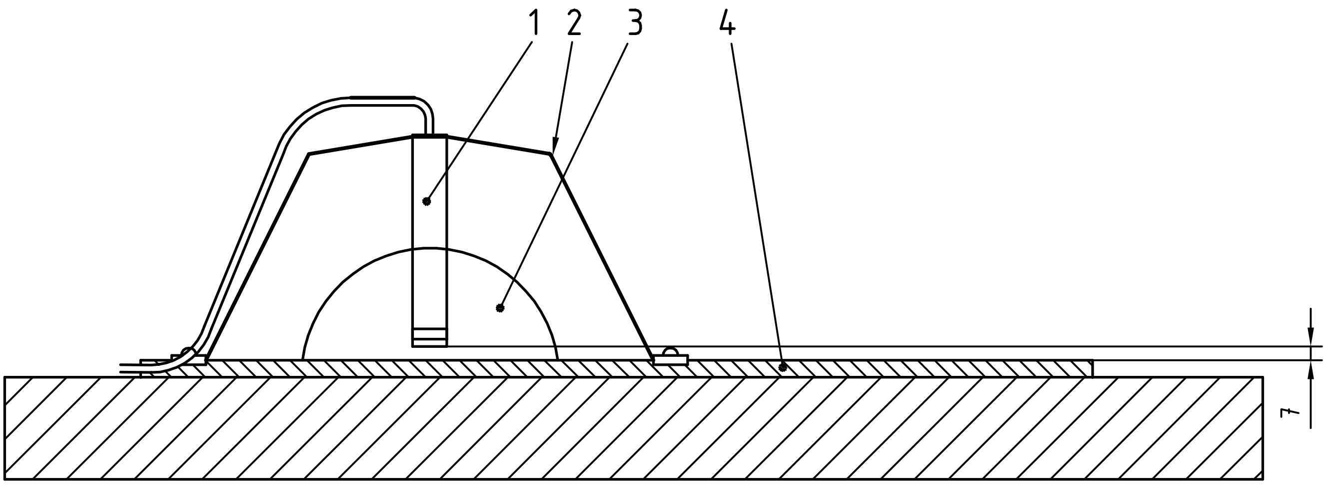
Figure 2 — Flat-plate method

The microphone shall be placed on a hard surface as shown in Figures 3, 4 and 5.

A metal plate of 2,5 mm thickness fulfils the requirement for an absorption coefficient of less than 0,06. Although this plate is shown in Figures 3 to 5, it is optional if the surface beneath fulfils the requirements.

Since this measurement method doubles the sound pressures relative to free-field measurements due to reflections from the flat plate, it is necessary to subtract 6 dB from the sound pressure level measured ($L_{p,\text{meas}}$) on the flat plate (see 7.3.2.1).

Dimension in millimetres



Key

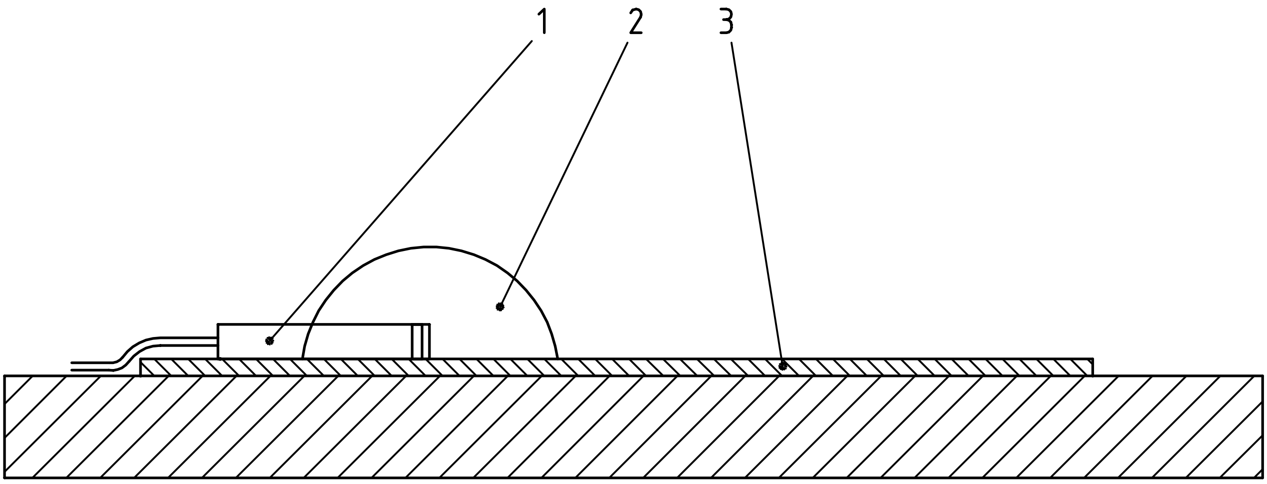
1 Microphone

2 Steel wire of 3-mm diameter, e.g. 3 pieces

3 Windshield

4 Hard plate

Figure 3 — Inverted microphone (in accordance with reference [3])



Key

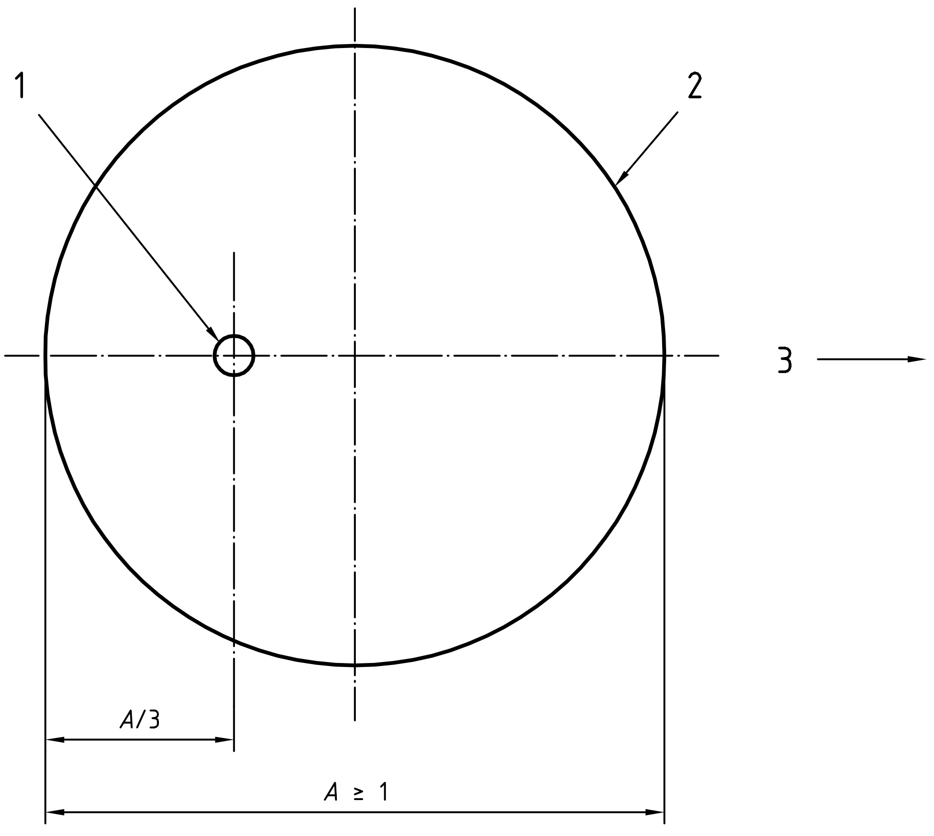
1 Microphone

2 Windshield

3 Hard plate

Figure 4 — Microphone on its side

Dimension in metres



Key

1 Microphone location

2 Hard plate

3 Warning device

Figure 5 — Microphone location: Plan view of plate to be used outdoors

5.4.2 Measurements in a semi-anechoic room

The quality of the semi-anechoic room shall fulfil the requirements of annex C with the microphone placed on the hard surface (see Figure 2).

5.4.3 Flat-plate measurements outdoors

A typical set-up for a flat plate with perpendicular incidence is shown in Figure 2.

The ground surface beneath the siren shall be acoustically hard (concrete or asphalt), flat and horizontal up to a distance of 5 m from the microphone, or the test site shall conform to the requirements given in 5.2.

The distance from the microphone to any reflecting objects shall be larger than 5 d.

6 Test conditions

6.1 Test site qualifications

The adequacy of the test site for measurements according to this part of ISO 13475 shall be established using the procedures of annex C for relevant measurement distances and frequencies.

6.2 Mounting of apparatus

The siren shall be mounted on the test site so that the acoustic requirement of the measuring line according to annex C can be fulfilled. Any devices necessary for fixing the siren shall be present during the qualification procedure.

Power supply conditions shall be in accordance with annex A.

6.3 Instrumentation

6.3.1 Equipment for determination of the sound pressure level

The sound level meter or the equivalent measuring system, including the windshield as recommended by the manufacturer, shall fulfil the requirements of a class 1 sound level meter according to IEC 61672-1. The diameter of the microphone shall be smaller than or equal to 13 mm, when using the plate method specified in 5.4.1.

Very high sound pressure levels might be encountered in these tests. Ensure that the high pressure limitation of the microphone capsule is not exceeded.

6.3.2 Equipment for determination of octave and one-third-octave band spectra

In addition to the requirements given for class 1 sound level meters, the filters shall meet the requirements of IEC 61260, class 1; parallel filters are preferred.

The equivalent continuous sound pressure levels shall be determined simultaneously in octave or one-third-octave bands with centre frequencies from 50 Hz to 4 000 Hz.

6.3.3 Calibration of the complete sound measuring system

The calibration of the complete sound measuring system, including any recording, data logging, or r.m.s. computing systems, shall be checked immediately before and after the measurement session at one or more frequencies using an acoustical calibrator on the microphone. The calibrator shall fulfil the requirements of IEC 60942, class 1, and shall be used within the specified environmental conditions.

If a difference of 0,5 dB or more appears between subsequent calibration sessions, the instruments shall be checked and the measurements shall be rejected.

6.3.4 Traceability of calibration of the equipment

All equipment for sound measurements shall be checked regularly and shall be calibrated with traceability to national standards. Calibration intervals for sound level calibrators shall not exceed 12 months, and for other equipment, 24 months.

6.3.5 Ambient conditions

The vertical wind speed gradient on the line of measurement shall not exceed 0,5 m/s per meter.

The maximum wind speed at the height of the centre of the siren shall be less than 3 m/s. The temperature, humidity, barometric pressure and wind speed shall be recorded according to clause 8.

Background noise shall be at least 20 dB lower than the signal level, with the C-weighting applied, measured over a period similar to the signal duration.

6.4 Test procedure

During the measurement, any specification from the manufacturer concerning the duty cycle (the ratio between the signal on time and the signal off time) and/or cool down time or temperature (of any system components) after signalling shall be observed. If any limitations exist, they shall be stated in the test report.

Any noise events unrelated to the characteristics of the generated sound level from the warning device under test shall not be taken into account.

Supply conditions and power consumption shall be recorded during sound power measurements.

Significant variations in $L_{p\mathrm{Ceq},T}$ with the supply conditions shall be recorded.

During measurements of frequency characteristics and directional characteristics, a power supply other than the supply integrated in the siren unit may be used.

7 Acoustic characteristics

7.1 General

To comply with this part of ISO 13475, a number of mandatory parameters shall be tested as given in Table 2.

In addition a number of optional parameters are mentioned which supplement the mandatory information. All parameters and how they are obtained are described in the following clauses.

7.2 Test signals

7.2.1 General

The tests shall be performed with signals appropriate for the use in the warning system. These signals may differ from the signals provided by the built-in signal source.

If the signal and/or the output of the siren can be influenced by external controls, the settings of these shall be chosen such that the test shall be representative for the use in the warning system; the settings shall be recorded carefully.

Table 2 — Acoustic characteristic parameters

Measured parameter	Result	Priority [a]
Temporal signal pattern of input signal Frequency variation of input signal	Graphical or verbal description of signals	M M
Equivalent sound pressure level on axis	$L_{W\,\text{Ceq,imm}}$ $L_{p\text{Ceq,30m}}$	M M
Maximum sound pressure level on axis	$L_{W\,\text{Cmax,F,imm}}$ $L_{p\text{Cmax,F,30m}}$	M M
One-third-octave spectrum (L_{eq}) on axis	$L_{W\,\text{eq,imm, 1/3 oct}}$ $L_{W\,\text{eq,imm,30m}}$	M M
Horizontal directional characteristics	$L_{p\ \text{1/3 oct}}$ $L_{p\text{C oct}}$	M M
Vertical directional characteristics	$L_{p\ \text{1/3 oct}}$ $L_{p\text{Cmax,peak}}$	O O
Narrow-band analysis	Spectrum $L_{p/\text{bandwidth}}$	O
Frequency response	Frequency characteristics	O
Noise from sirens	Noise immission	O
Power consumption	Electrical power	O

[a] M = mandatory, O = optional

It should be noted that the properties of signals used in the test will have a significant influence on the test results and should therefore be chosen so that they are representative of the intended use.

Some sirens may be supplied with signals from an external signal source. If this is done (e.g. for measuring frequency characteristics or testing the sirens with signals not included in the system), the test signals shall be described carefully.

The duration of the measurement of the sound emission quantities of the siren shall be representative of the character of the test signal and shall be at least 10 s long. If the signal emitted by the siren is periodical with a period longer than 10 s, the measurement duration shall be as long as the signal period.

Furthermore, a long integration time is desirable because it minimizes uncertainty caused by inaccurate time weightings, start transients of the signals, and the influence of internal heating in the sound source during the time of the signal.

A description of signals, including their frequency analysis and temporal distribution, is mandatory.

The information supplied by the manufacturer describing the signals shall be included in the test report. If this information is not available or if verification is needed, the signals may be measured according to 7.2.2 and 7.2.3.

7.2.2 Temporal distribution

If the on and off time of the input signal is part of an automatically generated signal characteristic and this temporal distribution of the signal shall be measured. A graphical presentation of the sound pressure level (with linear frequency weighting) versus time is recommended.

NOTE It may be necessary to use shorter time constants than F for the recording.

If the signal duration is set automatically, the total duration of the signal shall be measured.

It shall be stated whether the duration, timing and any delay between activation and sound output are in accordance with the relevant specifications.

7.2.3 Temporal variation of the frequencies

For input signals whose fundamental frequency varies with time, the variation shall be measured.

Various methods exist, as follows.

a) A series of successive FFT frequency analyses may be performed. Information on the variation of the fundamental frequency may be extracted or the results may be displayed as a waterfall diagram.

b) Equipment for tracking frequency analysis often contains a d.c.-output voltage which is proportional to the frequency or the logarithm of the frequency. This d.c. voltage may be measured to infer frequency variations.

c) Frequency to voltage converters may be used.

CAUTION — For methods b) and c), a check shall be made as to whether any sweep rate limitations in the converter and/or content of higher harmonics and/or amplitude variations in the signals will give rise to significant measurement errors.

7.3 Determination of the sound emission quantities

7.3.1 Readings to be taken

During the time period required according to 7.2 the following quantities shall be recorded.

a) $L_{p\mathrm{Ceq},T,d,\mathrm{meas}}$ the C-weighted equivalent continuous sound pressure level and one-third-octave-band equivalent continuous sound pressure levels over a time interval T at distance d;

b) $L_{p\mathrm{Cmax,F},d,\mathrm{meas}}$ the C-weighted and one-third-octave-band maximum sound pressure levels, determined with time weighting F at distance d.

The distance d is the distance between the measuring microphone and the acoustical centre of the siren.

It is recommended that the measurements be performed in one-third-octave bands.

When the frequency spectrum of the total signal is known, it is possible to calculate the influence of a frequency-dependent sound propagation. The influence of any frequency weighting (e.g. A-weighting or frequency-dependent sound insulation of building elements or hearing protectors) may also be calculated.

NOTE One-third-octave-band analysis is preferred rather than octave-band analysis because octave bands can be calculated from one-third-octave bands.

7.3.2 Corrections to readings

7.3.2.1 Method using a free field over a reflecting plane

Correct the recorded sound pressure levels, obtained on a reflecting plane, according to equations (3) and (4) to compensate for the pressure doubling caused by the reflection, thus obtaining the free field sound pressure level.

$$L_{p\mathrm{eq},T,d} = L_{p\mathrm{eq},T,d,\mathrm{plate}} - 6\ \mathrm{dB} \qquad (3)$$

$$L_{p\mathrm{max,F},d} = L_{p\mathrm{max,F},d,\mathrm{plate}} - 6\ \mathrm{dB} \qquad (4)$$

NOTE No information concerning the total radiated acoustic power can be drawn from the calculated immission-relevant sound power level.

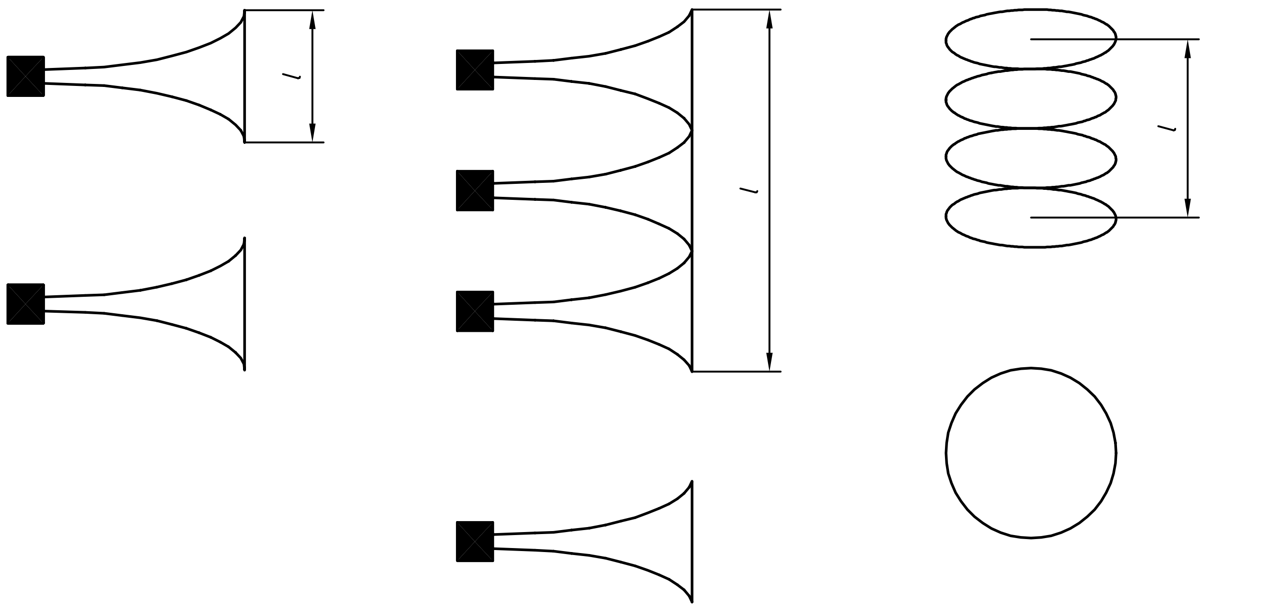
7.3.2.2 Correction for near-field errors

When using a measurement distance in the near field of the sound source under test, the measurement distance d shall be within the limits:

$$\frac{l^2 \cdot f}{4{,}5 \cdot c} < d < \frac{l^2 \cdot f}{c}$$

where l is the largest vertical dimension of the sound opening including all sound-emitting parts.

Examples of these distances are given in Figure 6.



a) Single directional horn b) Stacked directional horn c) Stacked omnidirectional horn

Figure 6 — Examples of the largest vertical dimension of the sound opening

The corrections for near-field errors may be applied to the one-third-octave bands according to Figure 7 and equations (5) and (6):

$$\text{Near-field error} = 20 \lg \left[\frac{\left| \frac{\sin(k_1 \xi)}{k_1 \xi} \right|^E + k_2}{(1 + k_2)(1 + k_3 \xi)} \right] \text{dB} \quad (5)$$

where

$$\xi = \frac{l^2}{d \cdot \lambda} \quad (6)$$

$k_1 =$ 0,44

$k_2 =$ 0,44

$k_3 =$ 0,025

$E =$ 1,19

NOTE Taken from bibliographic reference [4].

The correct C-weighted value is obtained by summation of the one-third-octave bands:

$$L_{p\mathrm{C}} = 10 \lg\left(\sum_{i=125}^{4000} 10^{(L_{pi} + w_{\mathrm{C}i})/10} \right) \mathrm{dB}$$

where

L_{pi} is the sound pressure level in the i th one-third-octave band between 125 Hz and 4 000 Hz;

$w_{\mathrm{C}i}$ is the corresponding C-weighting.

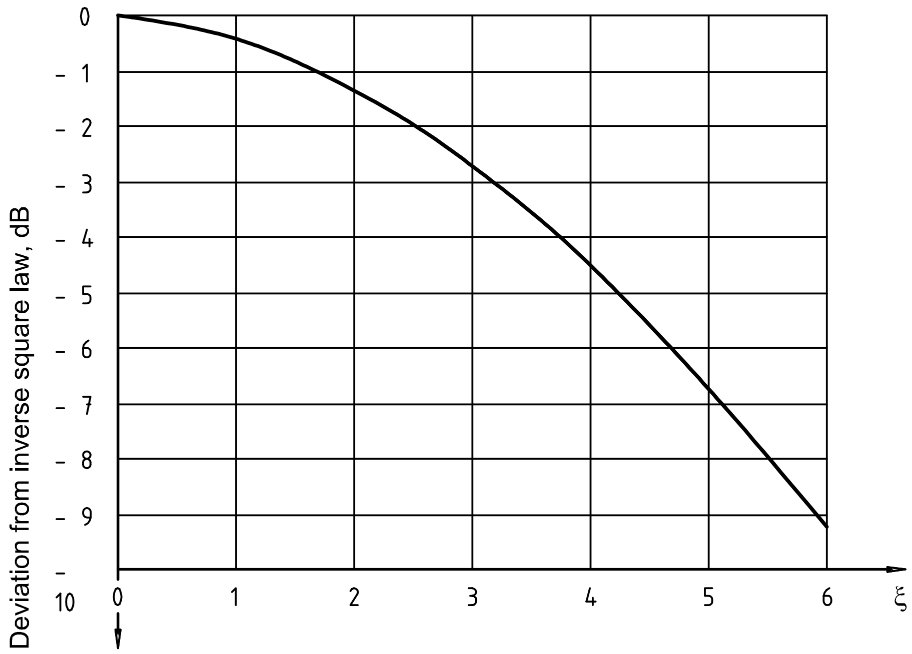


Figure 7 — Corrections for near-field errors

7.3.3 Processing of recorded data

Convert the corrected sound pressure level values from the actual measuring distance d to a reference distance of 30 m according to equations (7) and (8):

$$L_{p\mathrm{eq},T,30\mathrm{m}} = L_{p\mathrm{eq},T,d} + 20 \lg(d/30)\ \mathrm{dB} \quad (7)$$

$$L_{p\mathrm{max,F},30\mathrm{m}} = L_{p\mathrm{max,F},d} + 20 \lg(d/30)\ \mathrm{dB} \quad (8)$$

Calculate the immission-relevant equivalent sound power level $L_{W\mathrm{eq,imm}}$ according to equation (9):

$$L_{W\mathrm{eq,imm,plate}} = L_{p\mathrm{eq},T,30\mathrm{m,plate}} + 40\ \mathrm{dB} \quad (9)$$

Calculate the immission-relevant maximum sound power level $L_{W\mathrm{max,imm}}$ according to equation (10):

$$L_{W\mathrm{max,imm}} = L_{p\mathrm{max,F},30\mathrm{m}} + 40\ \mathrm{dB} \quad (10)$$

NOTE No information concerning the total radiated acoustic power can be drawn from the calculated immission-relevant sound power level.

7.4 Directional characteristics

The directional characteristics in the horizontal plane under normal conditions shall be measured.

Measurement of the directional characteristics in the vertical plane relative to normal mounting conditions is optional.

NOTE 1 The vertical directional characteristic is appropriate for the following reasons:

a) data are needed for the field test using the flat-plate method, requiring a correction for not tilting the siren;

b) for calculating hearing damage risks beneath the siren;

c) for planning purposes using large mounting heights.

For evaluating the risks of hearing damage near and under the sirens, measurement of the maximum sound pressure level with time weighting peak shall be performed in relevant directions.

NOTE 2 The information on the maximum peak level may be used to estimate the risk of hearing damage. A-weighting or C-weighting may be chosen according to national standards.

It is recommended that directional characteristics be measured either by rotating the sound source or by rotating the microphone around the sound source, so that a continuous recording can be obtained.

The speed of rotation during testing shall be such that it is possible to construct (on the recording or by eye) the envelope of any maxima on the graph arising from pulsed or swept signals.

If the directional characteristics are obtained by measurements at a number of fixed microphone positions, care shall be taken that all peaks and dips are registered.

The measurements may optionally be performed in one-third-octave bands, A-weighted or C-weighted with the inherent sound signals.

7.5 Frequency characteristics

7.5.1 Instantaneous frequency spectrum

To facilitate computation of the audibility of signals above the background noise, at least one instantaneous spectrum of the signal shall be measured.

A narrow-band spectrum of the signal is recommended. For signals whose pitch varies with time, the spectrum shall be measured as part of the signal, or the spectrum shall be measured with a short integration time to avoid blurring of the harmonics.

NOTE It is recommended to use narrow-band analysis of signals with tonal character for the following reasons.

a) Knowledge of the narrow-band spectrum is essential when the audibility of the signals in the background noise is to be computed.

b) If a one-third-octave-band spectrum is desired, it can easily be derived from the narrow-band analysis.

The time function of the signals (e.g. as printouts from a storage oscilloscope) may be given as supplement to the spectrum.

7.5.2 Frequency response

For sound sources based on loudspeakers or horn drivers, it may be relevant to measure the frequency response.

It is recommended that the frequency response be measured on the axis of the sound source, with a sine sweep at a level which is 10 dB lower than the normal output level for the system.

The frequency range of the device is defined as the range of frequencies in which the sound pressure level is less than 10 dB below the mean response averaged over a bandwidth of one octave in the region of maximum overall sound pressure level.

Sharp peaks and dips in the response curve narrower than one-eighth octave shall be neglected for both the upper and the lower limits.

7.6 Noise from sirens

Any noise from the siren in an off or standby state shall be measured as A-weighted sound pressure levels. Both L_{Aeq} values and maximum values with the time weighting F shall be given.

The measurements shall be performed either on axis under anechoic conditions or as sound power measurements, in accordance with the measurement method chosen for the other characteristics.

NOTE The origin of the noise from sound signalling devices may be, for example, noise from power amplifiers in electroacoustic devices.

7.7 Measurement uncertainty

The measurement uncertainty of the sound emission quantities shall be determined according to annex B, taking into account the specific geometrical and environmental conditions of the test.

7.8 Test signals

For comparison tests, the siren shall be tested with a standard test signal. The purpose is to test the siren at full power in the frequency range of interest for the particular application. The range of frequencies to be used may be specified by the user or the manufacturer of the equipment. The sweeprate of the signal is recommended to be in the range of one octave 5 s to 20 s. Care should be taken that significant peaks and valleys in the acoustic output of the system are clearly recognized.

The frequency range tested shall be described by its start and end frequency; the frequency steps and the sweeprate shall be reported.

8 Information to be reported

The test report shall include the following information:

a) reference to this part of ISO 13475;

b) name and address of the organization (testing laboratory) performing the tests;

c) identification number of the test report;

d) name and address of the organization or person who ordered the test;

e) name and address of the manufacturer and supplier of the siren tested;

f) name and/or other identification marks of the siren tested;

g) list of documents identifying unambiguously the siren tested;

h) date of supply of the siren tested;

i) date(s) of the test;

j) test method;

k) identification and calibration dates of the test equipment and instruments used;

l) geometry, orientation and dimensions of the test site;

m) test conditions, viz. wind speed and direction, air temperature, barometric pressure and humidity;

n) description of the test signals with respect to frequency content and temporal distribution; settings of external controls, if any;

o) mandatory test results:

— in one-third-octave-band levels and C-weighted levels:

$L_{p\mathrm{eq},T,d,\mathrm{meas}}$

$L_{p\mathrm{max,F},d,\mathrm{meas}}$

$L_{p\mathrm{eq},T,\mathrm{30m}}$

$L_{p\mathrm{max,F,30m}}$

$L_{W\mathrm{eq,imm}}$

$L_{W\mathrm{max,imm}}$

p) directional characteristics in the horizontal plane;

q) optional test results: directional characteristics in the vertical plane;

r) uncertainty of the test results;

s) background noise:

$L_{p\mathrm{Ceq,back}}$ and $L_{p\mathrm{Cmax,back}}$

t) date and signature.

It is recommended that the test conditions and measurement results be reported according to the data sheet given in Table 3.

Table 3 — Example test report — Test measurement summary

Siren		**Model**	
Manufacturer		**Serial number**	
Description			
Test requested by:			
Test organization	Date	Time	
Personnel		Title	
Measurement location		Address	
Temperature, °C			
Wind speed, m/s			
Relative humidity, %			
Instrumentation	Manufacturer	Serial number	Calibration date
Calibrator			
Field calibration	Before test	After test	
Background noise			
Siren output			
Signal type			
L_{eq} **integration time**			
Measurement method	Flat plate tilt:	Horizontal	
Sound pressure level (ref. 20 µPa), C-weighted, dB			
$L_{p\text{Cmax,F}}$	At measurement distance ... m	$L_{p\text{Ceq}}$	At measurement distance ... m
$L_{p\text{Cmax,F}}$	At 30 m	$L_{p\text{Ceq}}$	At 30 m
Immission-relevant sound power level (ref. 1 pW), C-weighted, dB			
$L_{W\text{Cmax,F}}$		$L_{W\text{Ceq}}$	
Measurement uncertainty			
Remarks on test procedure		**Date of report**	**Signature**
Description of signal			
Description of test site			
Description of frequency characteristics			
Description of directional characteristics			

Annex A
(normative)

Supply conditions

During testing the device shall be powered from a source giving the nominal voltage, frequency, air pressure, etc. to within 5 % of the specifications given by the manufacturer. If a nominal range is specified, the average of that range shall be used during the testing.

If the sound pressure level, sound power level, signal frequency, or signal timing depends significantly on the power supply, the variations of these parameters shall be measured within the specified supply range of the device.

If the siren being tested is operated outside the limits of the nominal supply range, corrections for the resulting output power shall be provided by the siren manufacturer.

NOTE 1 According to this method, the nominal power supply conditions are normally checked at the supply terminals of the siren. Other related methods may give guidelines on how to simulate the resistance between supply source and siren.

Voltage, current or pressure may be used as the validation parameter.

It may be relevant to test the power consumption of the device. This test is optional. The mean of the total power consumption of the sound signalling device shall be measured at nominal power supply conditions. When measuring L_{eq} values, the equivalent voltage measured over the same period should be used. Both the consumption when signals are activated and when in any standby or power-down state, shall be measured.

Power consumption should be calculated from the supply conditions or measured directly during the measurements.

NOTE 2 The influence of using extraordinary long cables during the tests can be compensated for by documenting the influence and correcting the power supply.

Annex B
(normative)

Calculation of combined expanded uncertainty

B.1 Estimation of combined expanded uncertainty

The combined expanded uncertainty can be estimated by the following expression:

$$U = \sqrt{U_{\text{refl obj}}^2 + U_{\text{ground refl}}^2 + U_{\text{vert dir}}^2 + U_{\text{near field}}^2 + U_{\text{instr}}^2 + U_{\text{power}}^2}$$

where

$U_{\text{refl obj}}$ is the expanded uncertainty due to reflecting objects;

$U_{\text{ground refl}}$ is the expanded uncertainty due to reflection off the ground;

$U_{\text{vert dir}}$ is the expanded uncertainty due to the vertical directivity;

$U_{\text{near field}}$ is the expanded uncertainty due to near-field effects;

U_{instr} is the expanded uncertainty due to instrumentation;

U_{power} is the expanded uncertainty due to variation in power supply conditions.

Estimations of the expanded uncertainties due to the mentioned uncertainty sources are treated in detail below and are assumed to approximate a 95 % confidence interval.

B.2 Reflecting objects

Uncertainties due to reflecting objects can be evaluated from Table B.1 giving the estimated expanded uncertainties, $U_{\text{refl obj}}$ as a function of the ratio of the reflected signal path to the direct signal path.

Table B.1 — Estimated expanded uncertainty

Ratio of reflected/direct path	2	3	4	6	8	10
$U_{\text{refl obj}}$, dB	3	2	1	< 1	< 1	≈ 0

B.3 Ground reflection effects

Errors due to reflection off the ground are estimated as shown:

$U_{\text{ground refl}}$ = 0,5 for the horizontal measurement method, and

$U_{\text{ground refl}}$ = 0 for the flat-plate method.

B.4 Vertical directivity

If the flat-plate method is applied without tilting the warning device, a correction for the sound pressure can be applied according to the vertical directivity. This can be obtained by the method described in this part of ISO 13475. Use the vertical characteristics when the tilt is not used. $U_{\text{vert dir}}$ is the uncertainty in determination of the vertical directivity.

B.5 Near-field effects, flat-plate method

Uncertainties due to near-field effects in stacked-array speaker units are calculated according to equations (5) and (6) and Figure 7 in 7.3.2. To achieve an expanded uncertainty $U_{\text{near field}} < 0,5$ dB, the corrections shall be applied accordingly.

B.6 Instrumentation

Typical estimation of the expanded uncertainty for the instrument chain is

U_{instr} = 0,7 dB for class 1 instrumentation;

U_{instr} = 2 dB for class 2 instrumentation.

B.7 Power conditions

Estimations of the expanded uncertainty due to variations in the power supply of the siren during the test are achieved by registration of systematic variations in power supply and acoustic output.

B.8 Example

In Table B.2 a typical precision measurement set-up is assumed. The power is assumed to be constant, giving no variation in output power.

Table B.2 — Estimate of uncertainties in a typical measurement set-up

Parameter dB	Free-field method	Free field over a reflecting plane
$U_{\text{refl obj}}$	0,5	0,5
$U_{\text{ground refl}}$	0,2	0
$U_{\text{vert dir}}$	0	0
$U_{\text{near field}}$	0,5	0,5
U_{instr} (class 1)	0,7	0,7
Combined U	1,0	1,0

Annex C
(normative)

Test site qualification procedures

C.1 General

A laboratory room providing a free field (anechoic room) or a free field over a reflecting plane (semi-anechoic room) may be used for measurements made in accordance with this part of ISO 13475. See also ISO 3745.

The test room shall be large enough and free from reflecting objects with the exception of the reflecting plane in a semi-anechoic room. The test room shall provide a measurement line

a) in a sound field which is free of undesired sound reflections from the room boundaries (free-field condition),

b) outside the near field of the sound source under test ($\xi < 1$, see 7.3.2.2).

If condition b) cannot be fulfilled, see 7.3.2.2 for corrections ($1 < \xi < 4{,}5$).

Alternatively an outdoor measuring site may be chosen. A procedure is described in this annex to determine the undesired environmental influences (if any) and to check the free field conditions. For measurements with the flat-plate method, the reflecting plane shall have an absorption coefficient less than 0,06 over the frequency range of interest.

C.2 Sound pressure decay test of the test site

C.2.1 Instrumentation

C.2.1.1 Test sound source

An electroacoustic system with loudspeakers shall be used. The sound radiation shall be omnidirectional with deviations less than ±1 dB, within the frequency range to be used in the test.

It is recommended that different sources be used for different frequency ranges, for example:

— < 400 Hz: electrodynamic loudspeaker 25 cm in diameter in closed, damped 0,020 m^3 box;

— 400 Hz to 2 000 Hz: two electrodynamic speakers, 10 cm in diameter, bolted together so that their mounting rings lie in the same plane and electrically connected as a pulsating “sphere”;

— 2 kHz to 10 kHz: loudspeaker system with a narrow cylindrical tube (< 1,5 cm diameter) the end section of which only radiates the sound.

C.2.1.2 Microphone

The sensitivity of the microphone shall be omnidirectional with deviations less than ±1 dB within the frequency range to be used in the test.

The use of a 13 mm (1/2 inch) microphone conforming to IEC 61672-1 will fulfil the requirement.

C.2.2 Installation of test source and microphone

C.2.2.1 Free-field measurements

The test sound source shall be located in essentially the same positions as that of the source under test. The microphone shall be located on the measurement line.

C.2.2.2 Free-field measurements over a reflecting plane

The test sound source and the microphone shall be located on the measurement line.

The microphone shall be located on the hard surface in the normal position according to the procedure given in 5.4.

C.2.3 Test procedure

The electroacoustic system described above shall be operated in discrete frequencies which cover in discrete octave steps the entire frequency range of interest for the sound source under test (the octave bands centred around 125 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz and 4 000 Hz).

The test source or the microphone shall be moved continuously along the paths described above for each frequency and the sound pressure levels recorded.

C.2.4 Qualification procedure

The recorded levels shall be compared with the decay predicted by the inverse square law and the differences between the measured and the theoretical levels shall be calculated for each path and each test frequency.

The differences shall not exceed the values given in Table C.1.

Table C.1 — Maximum allowable differences between the measured and theoretical levels

One-third-octave-band centre frequency Hz	**Allowable differences** dB
$\leqslant$ 500	$\pm$ 1,5
1 000 to 4 000	$\pm$ 1,0

If these conditions cannot be satisfied, measurements cannot be performed in accordance with this part of ISO 13475 as the test site fails to qualify.

Bibliography

[1] ANSI S12.14, *Methods for the field measurement of the sound output of audible public warning devices installed at fixed locations outdoors*.

[2] NT ACOU 081, *Nordtest Method — Sound signalling devices — Acoustic emission.*

[3] *International Standards and Recommended Practices, Environmental Protection*, Annex 16, Vol.1, *Aircraft Noise*, 3rd edition, 1993, ICAO, Montreal, Canada.

[4] Technical Note AV743/96, Torben Holm Pedersen, *Near Field and Ground Reflection Errors, Delta Acoustics & Vibration*, Denmark, 1996.

[5] *Guide to the expression of uncertainty in measurement* (GUM), BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1993.

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